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Inventor(s):   William D. Hall

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MOTION DISPATCH SYSTEM

BACKGROUND OF THE INVENTION

The advent of logistically complex businesses that operate fleets of vehicles to provide service to customers at varied locations, the advent of tightly scheduled services provided in-office, and the ever-increasing mobility of the populace create the need for advanced methods and systems for arranging meetings efficiently. Coordination of meetings between two or more parties has always required, at a minimum, that each party communicate his or her available times to the other. Logistics of each party's transportation to the meeting must be considered in the choice of the meeting schedule and location. Some delivery and service companies employ digital dispatch, communicating service instructions and delivery status between the vehicle and a dispatch center over a wireless digital link. Some services provide for dynamic arrangement of meeting locations using voice communications over a telephone or radio.

SUMMARY OF THE INVENTION

Service delivery to customer homes requires the customers to spend hours waiting because of the lack of information concerning the progress of deliveries to other customers. Missed service calls leading to repeat attempts at delivery are common and expensive for both parties.

Systems which employ digital dispatch require significant manual effort. The dispatch center must be staffed with trained dispatchers, and there is no flexibility in the process to accommodate customer scheduling preferences dynamically, nor are there automatic mechanisms to keep the customer informed in real time about estimated time

5   of service. When the meeting involves more than two parties, the communication logistics between parties can result in meeting locations and schedules that are very inefficient. Systems which implement dynamic adjustments of meeting locations and/or schedules also require considerable manual effort. Further, at least one party must be familiar with the geographic area in which the meeting is to take place.

10   The present invention implements a system that uses real-time information from a variety of sources to coordinate meetings between parties. For example, the system may be deployed to coordinate meetings between customers and representatives of a company that delivers products or services to customers at many, possibly dynamically determined locations. It may also coordinate meetings between independent parties,

15   such as mutual friends traveling to a meeting point to be determined, or realtors from several realty offices and their collective customers on a busy day.

The system manages communications between the meeting parties and accounts for the objectives and constraints of each party to generate an efficient schedule for one or both parties. For example, the system accounts for the service provider's fleet

20   logistics, uncertainty in service times and variability of travel times on the road, and it dynamically schedules the fleet of vehicles and the customers' appointment times to realize an efficient operation that is satisfying to the customers. The system may designate the times and/or locations of meetings, which it coordinates through one or more of a variety of communications means. Also, dynamically updated data from a

25   variety of sources may cause the system to reschedule meetings. For example, unexpected road network traffic congestion resulting in delays may cause the system to rearrange meetings scheduled later in the day. The system is capable of handling future uncertainty through the use of schedule time windows and/or meeting regions which become more precise as the schedule uncertainty lessens over time.

The present invention implements a system for coordinating meetings between parties. Specifically, a database for the system stores meeting data which includes indications of meetings to be held and potential parties that may attend the meetings and the relevant locations of the parties. The data also includes indications of the relevant location of certain parties, such as those who will actually attend the meetings, and their real-time location. A scheduler and a communications system are coupled to the database. The scheduler generates and updates proposed meeting schedules and stores the proposed meeting schedules in the database. The proposed meeting schedules include meeting data, time, location and parties attending based on the meeting data stored in the database. The communication system provides information regarding the meetings to be held and the proposed meeting schedules.

Embodiments of this aspect may include one or more of the following features. The system may include a tracker coupled to the database. The tracker detects real-time, current locations of the certain parties and provides indications of these locations to the database. Data from the meeting participants may enter the database through several means, and data from the database may be communicated to potential meeting participants through several means. Potential meeting participants' objectives may be elicited and used to determine the meeting schedule. Predicted service times and service time probability distributions may be used to estimate the time at which service can be provided.

The following features may also be included. The service time predictions and probability distributions may be used to estimate the time window required to meet service time guarantees. For example, the service provider may want to meet the quoted time window at least 95% of the time. The service descriptions and the time required to perform them may be recorded to improve the statistical models of the service time required. The meeting locations may be measured by navigation systems and recorded in a separate database for later retrieval. Characteristics of the meeting from the database may be recorded along with associated meeting participant communications for

statistical analysis and later retrieval. Potential meeting participants may be represented through Boolean logic. Meeting timing and location constraints for a potential meeting participant may be based on direct measurement of time and location preference.

5   Users with navigation systems, such as GPS (Geographic Position Systems), in communication with the system may specify the meeting participants and their mobility characteristics, and have the system coordinate the meeting location and time based on the participants' abilities to reach each other.

Meeting timing and location constraints for a potential meeting participant are based on other meetings the participant is to attend, for those potential participants for 10 whom the system is coordinating more than one meeting.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference 15 characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Fig. 1a is a schematic diagram of a motion dispatch system in accordance with the present invention.

20   Fig. 1b is a flow chart of a sequence of steps performed to select an operation mode of the motion dispatch system of Fig. 1a.

Fig. 2 is a flow chart of a sequence of steps performed when the motion dispatch system of Fig. 1a operates in a fully-automatic mode.

Fig. 3 is a flow chart of a sequence of steps performed when the motion dispatch 25 system of Fig. 1a operates in a fully-dispatched mode.

Fig. 4 is a flow chart of a sequence of steps performed when the motion dispatch system of Fig. 1a operates in a participant-ordered mode.

Fig. 5 is a flow chart of a sequence of steps performed when the motion dispatch system of Fig. 1a operates in a dispatched-ordered mode.

DETAILED DESCRIPTION OF THE INVENTION

Turning attention now to the drawings. Fig. 1a illustrates a motion dispatch
5   system 10 which uses three commercially available computer systems 12a, 12b, and 12c, each having a CPU 14 and a database 16. Each computer system 12a, 12b, 12c also stores a software routine 17 to implement the motion dispatch system 10. The databases 16 store identical information to prevent the catastrophic loss of information in the event that one or two computer systems fail. The system 10 communicates
10   meeting information (time and location) to the participants of the meetings through telephones 18 and paging systems 20 connected to an interactive voice response (IVR) system 22, through browsers 24 of web servers 26 connected to the Internet 28, and through wireless devices 30 (e.g. digital communications text/graphics devices), over cellular communications systems 32, carried on the participants or in the vehicles of the
15   participants. The motion dispatch system 10 uses database software, IVR systems, and custom software written in C, C++, java, and perlscript.

Referring now to Fig. 1b, the system 10 operates in one of four dispatching modes. Specifically, a parameter is set according to a system-wide default 50, which may be over-ridden by a participant-specific default 52, which in turn may be over-
20   ridden by a meeting-specific default 54. The parameter, for any given meeting, takes one of the following values: a fully-automatic mode 56, a fully-dispatched mode 58, a participant-ordered mode 60, or a dispatch-ordered mode 62.

The operation of the fully-automatic mode 56 is depicted in greater detail in Fig. 2. In a first step 70, the system 10 queries each meeting participant for the times that he
25   or she can participate in system-arranged meetings. Next in a step 72, the system converts schedule information into constraints of the form

$$x_{ijk} \leq feas_{ijk}, \forall i,j,k \qquad (1)$$

$$\sum_{j \in T} x_{ijk} \leq 1, \forall i,k \qquad (2)$$

$$\sum_{k \in K} x_{ijk} \leq 1, \forall i,j \qquad (3)$$

$$\sum_{i \in I(k)} \sum_{j \in T} x_{ijk} \leq N(k), \forall k \qquad (4)$$

$$y_{ik} = \sum_{j \in T} x_{ijk}, \forall i,k \qquad (5)$$

$$\sum_{i \in I(k)} y_{ik} \geq R(k), \forall k \qquad (6)$$

$$x_{ijk} \in \{0,1\}, \forall i,j,k \qquad (7)$$

$$y_{ik} \in \{0,1,2,...\}, \forall i,k \qquad (8)$$

Where the x_{ijk} are binary 0-1 variables that represent an assignment of participant i to meeting k at time j when set to 1. Time is discretized into the set T of time periods over which the meetings must take place. K represents the set of meetings under consideration by the system, $I(k)$ is the set of participants who may attend the meeting, $N(k)$ represents the maximum number of meeting participants allowed, and $R(k)$ represents the number of participants required to hold the meeting. Constraints (1) - (8) may be supplemented by the addition of constraints on the y_{ik} allowing Boolean logic to determine the meeting participants.

Furthermore, in a step 74, travel time constraints are required so that each meeting participant has enough time between meetings to complete the business of each

meeting and to travel between them. One approach to incorporate these constraints is to form the matrix A in which element $a(k,k')$ is the time required to complete meeting k and travel to meeting k'. Then the constraints:

$$x_{ijk} + \sum_{j \leq j' \leq j+a(k,k')} x_{ij'k'} \leq 1, \forall i,j,k,k' \qquad (9)$$

5   prevent meetings from being scheduled too close together in time.

Finally, in a step 76 variables z_{jk} are defined to indicate meeting times for use in the objective function:

$$z_{jk} = \sum_i x_{ijk}, \forall j,k \qquad (10)$$

that is, $z_{jk} = 1$ if meeting k is to occur at time j. These variables allow an objective

10   function of the form

$$\max \sum_j \sum_k v_{jk} z_{jk} \qquad (11)$$

which can be adjusted through the objective coefficients v_{jk} to reflect any desired meeting timing and priority objectives.

In a step 78, these constraints and objectives are sent to a commercial

15   optimization library to generate an optimal solution. Alternatively, in a step 80, large sets of data with highly constrained resources are better handled through a mixed heuristic-optimization approach, such as the composite variable formulation applied by Armacost to the optimization of overnight package delivery. (See, Armacost, Andrew P., "COMPOSITE VARIABLE FORMULATIONS FOR NETWORK DESIGN," Ph.D.

20   Thesis in Operations Research, Massachusetts Institute of Technology, June 2000.) In the heuristic-optimization approach, heuristics are used to generate partial meeting schedule candidates. These partial meeting schedule candidates are then pieced together by optimization. Then in a step 82, a schedule solution is generated. The schedules are then relayed to the participants 84 directly, or to the dispatchers 86 who communicate

the schedule information to the participants. Communication is though Internet 28/browser 24, IVR 22/phones 18, pagers 20, or wireless systems and channels 32, 30.

In sum, when the motion dispatch system 10 operates in the fully-automatic mode 56, meeting timing, location, and participant constraints are formulated from the appropriate information in the database 16. Objectives are formulated from the meeting times. The resulting optimization problem is solved by standard optimization techniques. Optionally a commercial optimization library may be employed to determine the meeting times and locations. When the motion dispatch system 10 operates in this mode, the system arranges meetings without intervention of a dispatcher.

For meetings that are fully dispatched, the system 10 does not optimize meeting schedules. Rather, as shown in the sequence of steps illustrated in Fig. 3, the system in fully-dispatched mode 58 first queries the participants, in a step 90, as to their schedules, and then displays schedule information to dispatchers in a step 92 subject to travel time constraints 94 and schedule constraints 96. That is, as the dispatchers interact with the system to schedule meetings, the system notifies the dispatchers of any violations of the constraint set (1) – (8) from above caused by the dispatchers' collective schedules. Next, in a step 98, through its communication mechanisms 18, 20, 22, 24, 26, 28, 30 (Fig. 1a), the system 10 informs each of the meeting participants of the status, such as location and time of arrival, of other participants coming to the meetings, and of schedule changes by the system.

Note, the meeting participants may communicate service time estimates. If the system 10 determines that it can generate an improved meeting schedule (time and/or location), it communicates the updated schedules to the participants. Schedule changes are implemented only if the probability of success of implementing the new schedule is adequately high. That is, for example, if the net expected benefit of the schedule change is positive as suggested by the following formula:

$$P_s \times \Delta_s > P_F \times C_F$$

where P_s represents the probability of a successful meeting rescheduling, Δ_s represents the incremental benefit of successfully rescheduling the meeting, represents the probability that the attempt to reschedule cancels the meeting, and C_F represents the cost of canceling the meeting.

5   Thus when the system 10 operates in the fully-dispatched mode 58, the dispatchers propose the order in which meetings are to occur and the participants of each meeting. Using this information, the system 10 provides estimates of the times at which the meetings are to occur. The dispatchers may then propose a new meeting order. After a satisfactory meeting schedule is generated, the system 10 communicates

10   the implemented schedule to the meeting participants.

In some circumstances, the participants may want to determine the order of the meetings. Referring to Fig. 4, there is shown a process for scheduling meetings when the system 10 operates in the participant-ordered mode 60. Initially in a step 100 the system10 queries the participants as to their availability and then assigns meetings to the

15   participants. Then in a step 102, the participants, either collectively or according to participant decision priorities, determine the order of the meetings. Next in a step 104, this meeting order is communicated back to the system through a participant-to-system communication mechanisms (e.g. phone 18 to IVR 22, or browser 24/Internet 28 of Fig. 1a). In this step 104, the system 10 updates the meeting schedules. Next, the system 10

20   communicates the updated meeting schedules to the participants 106 either directly or via the dispatchers 108 through communication mechanisms 18, 20, 22, 24, 26, 28, 30 described in Fig. 1a.

In essence, the meeting participants determine the meeting order, and communicates this information to the system 10 so that the system can estimate the

25   times at which meetings would occur. The dispatchers then assign the participants to the meetings. Further, the dispatchers may reassign meetings among the participants or the participants may choose a new order.

In other situations, a dispatcher-ordered process is more desirable. A process to implement the dispatcher-ordered mode 62 is illustrated in Fig.5. Here, in a step 120, the participants are first queried about their schedules. Next, in a step 122, the meeting order is determined by the dispatchers, and then in a step 124 the participants choose

5   which meetings they can attend. The dispatchers can use this mode 62 to schedule urgent meetings, for instance.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the

10   scope of the invention encompassed by the appended claims.

For example, a tracker (e.g. GPS-based) system of a participant may be in communication with the invention database subsystem 16. As such, real-time geographic location of the participant is indicated in the database 16 and employed by the system 10 in determining and communicating proposed meeting schedules.

15   Accordingly, video and/or audio and/or digital output is provided from the system 10 to the participants (through at least Internet 28/browser 24 and wireless systems 32, 30 of Fig. 1a).

Other tracking means include cellular positioning systems and cell phone locator systems.